Sir K. S. Krishnan *Prof. Rabi* *Prof. Francketti*
Prof. Cacciapuoti *Prof. Mandó*

I. I. Rabi, U. S. Delegate to the Fifth General Conference of Unesco, who was guest speaker at a lecture held at the University of Florence in conjunction with the conference, paused after his address to talk with the scientists shown here. Sir K. S. Krishnan is professor of physics at New Delhi University; Prof. Cacciapuoti heads the University of Trieste's institute of physics; Prof. Mandó and Prof. Franchetti are both of the University of Florence, the latter heading the University's institute of physics. In the background is the University's observatory located on the site where Galileo conducted many of his studies in astronomy.

of a number of European centers for pure research that Unesco might help in establishing. Ideally, he said, the laboratory should be equipped with a large accelerator, perhaps similar to cyclotrons now in operation at MIT, Columbia University, and Cornell University. The actual construction and maintenance of the laboratory should not be financed by Unesco, Dr. Rabi emphasized, but by joint action of the nations taking part in the project.

While the proposal was supported strongly by a number of the delegates from member nations, Unesco's program committee did not specify the physics laboratory as necessarily being a pilot project but called more generally for the creation of regional laboratories to promote the international collaboration of scientists. Several other suggestions have been made from time to time for Unesco-sponsored international laboratories—notably a European computing laboratory to act as a central agency for tackling problems requiring mathematical analysis, a center for research on the medical, psychological, and psychiatric problems relating to the brain, and a social science research center.

ELECTROMAGNETIC WAVES
SYMPOSIUM AT WASHINGTON SQUARE

A symposium on the theory of electromagnetic waves was held at New York University at Washington Square under the joint sponsorship of NYU and the Geophysical Research Directorate of the Air Force Cambridge Research Laboratory on June 6, 7, and 8, 1950.

Extensive applications in recent years in the fields of communications and radar and as a tool of physical research have resulted in widespread interest in electromagnetic theory. Because of the complexity of formulating the laws of electromagnetics very few problems are amenable to exact solution. Even approximate solutions suitable for applications are in many cases difficult to obtain. As the applications have grown more intricate, mathematical difficulties have become greater and correspondingly the complexity of the problems has aroused mathematical interest.

The particular interest of the Air Force in electromagnetic theory was discussed in one of the papers presented at the symposium by N. C. Gerson of the Geophysical Research Directorate. The approach of the Air Force to the problems of fundamental research and the various programs being sponsored in mathematical aspects of electromagnetics were outlined.

The purpose of this symposium was to bring together research workers representing a wide range of current research in various fields. The technical program consisted of 21 papers in applied mathematics, physics, engineering, and mathematical interpretation of experimental work. Over 200 people registered for the sessions, representing 24 universities, 18 industrial organizations, and 20 government laboratories. Three foreign countries were represented among the speakers: O. E. H. Rydbeck of the Chalmers Institute of Technology, Gothenberg, Sweden; H. Bremmer of the Philips' Research Laboratory of Eindhoven, Netherlands; and J. W. Cox of the Defence Research Board of Canada.

A number of social functions were arranged to provide opportunities for personal discussion among the registrants. Teas were held after the Tuesday and Thursday afternoon sessions and a dinner session was held on Wednesday night at the Fifth Avenue Hotel. Paul P. Ewald, of Polytechnic Institute of Brooklyn, was the after dinner speaker and presented an interesting talk on concepts,

models, and solutions in mathematical physics which, in addition to being thought provoking, included many interesting anecdotes in the development of mathematical physics in the early years of this century.

The scope of the symposium was limited to the classical theory of electromagnetics. Major problems treated may be classified rather arbitrarily under the headings: diffraction, optics and its relationship to electromagnetics, propagation in stratified media (in particular the troposphere and the ionosphere), guided waves, and some strictly mathematical problems related to these fields.

DIFFRACTION THEORY

Problems connected with various types of geometries in which exact solutions may be obtained were treated in several papers.

R. D. Spence and C. P. Wells of Michigan State College discussed the problem of vector wave functions which are solutions of the vector wave equation with special reference to spheroidal coordinate systems. Because this equation cannot be separated into ordinary differential equations, the usual eigen-expansions for boundary value problems are not available. In degenerate cases, which correspond to disk and aperture problems, suitable expansions may be obtained when special boundary conditions are applied. The determination of the singularities at the boundary remains an open problem.

J. B. Keller of New York University discussed the diffraction and reflection of pulses by wedges and corners. The approach was quite unorthodox in that he solved the pulse problem directly rather than by Fourier synthesis of time-harmonic solutions. This is achieved by an application, unusual in electromagnetic theory, of the method of conical flow which is commonly used in supersonic aerodynamics. Explicit solutions in terms of elementary functions can then be constructed.

S. N. Karp of NYU discussed a general class of diffraction problems in which exact solutions are possible. This paper gave an analysis and comparison of two well known methods, separation of variables and the Wiener-Hopf integral equation method for treating boundary value problems, in which the boundary consists of several separated parts. A classification of the problems for which the Wiener-Hopf method applies was given. It was shown that the essence of both methods is analytic continuation and that the two methods are practically coextensive in their range of application. This paper provided a point of departure for a lively exchange of views between S. A. Schelkunoff and Dr. Karp on the eternal question of the precise meaning of an exact mathematical solution to a physical problem.

Two papers discussed various approximation methods for diffraction problems. Dr. Schelkunoff, of Bell Telephone Laboratories, showed how generalization of Thevenin's and Norton's theorems for circuits can be used to obtain integral equations for the difference between the exact diffracted field and that obtained by the Kirchhoff formula. H. Levine of Harvard University discussed the application to electromagnetic problems of the powerful, recently developed techniques based on integral equations and variational principles. The value of such principles is based on the stationary properties of the diffracted field with respect to the variations relative to the correct tangential electric or magnetic fields on appropriate boundary surfaces.

S. O. Rice of Bell Telephone Laboratories presented a survey of methods which have been used to study various aspects of diffraction by rough surfaces. The lines along which current work is proceeding were indicated. Expressions for reflection coefficients and phase velocities for waves on a rough surface were obtained in terms of statistical properties of the surface.

RELATIONSHIPS BETWEEN OPTICS AND ELECTROMAGNETICS

H. Bremmer considered an optical system by starting with the solution of the wave equation in the object space which has prescribed values immediately behind the object plane. A procedure for obtaining the solution in the image space for the case of Gaussian optics was described and several properties of this solution were considered. In the discussion of this paper H. G. Booker of Cornell University pointed out the connection between Bremmer's approach and the alternative approach starting with the relationship between the plane wave spectrum of a disturbance and the field distribution in the aperture.

M. Kline of New York University presented a paper on asymptotic expansion of electromagnetic fields, in which the geometrical optics approximation appears as the first term. This expansion is in powers of wavelength and the coefficients of the series are the discontinuities of the pulse solution of Maxwell's equations. A method of determining these coefficients as the solutions of a recursive system of ordinary differential equations was given.

Dr. Bremmer presented a different type of expansion in which the WKB (Wentzel, Kramers, and Brillouin) approximation appears as the first term. A solution of the one-dimensional wave equation is built up by physical considerations of the reflections from discrete strata. This solution has the form of an infinite series, the n^{th} term of which is obtained by adding the contributions resulting from n consecutive reflections. The solution for a continuously varying medium is obtained by passing to the limit of infinitesimally thin strata and the first term of the resulting series then proves to be the WKB approximation. The possibility of an alternative approach to the same problem from purely mathematical considerations by the use of perturbation procedures on an integral equation formulation was suggested in the comments by Nathan Marcuvitz of the Polytechnic Institute of Brooklyn.

STRATIFIED MEDIA

Dr. Schelkunoff showed how the problem of propagation in such media can be formulated as a pair of first order ordinary differential equations. These equations are familiar in engineering as those for inhomogeneous transmission lines. J. B. Keller indicated that he had used a similar analysis for ionospheric problems and that the formulation in that case leads to a system of four first order equations, which may then be solved by the Peano-Baker matrizant method.

Professor Marcuvitz discussed the important case of propagation in spherically stratified media. Field representations of a radiating electromagnetic source in a spherically stratified medium may be effected by regarding either the radial or angular directions as transmission directions and the corresponding spectra possess different characters. The desirability of different representations becomes significant when the question of convergence rapidity is considered.

B. Friedman of New York University discussed the relationships between alternative formulations of the propagation problem for stratified media. A general method was described by which solutions obtained in eigenfunctions of the angular direction can be transformed into a solution in eigenfunctions of the radial direction.

IONOSPHERIC AND TROPOSPHERIC PROPAGATION

Two important applications of the general theory of stratified media are the propagation in troposphere and ionosphere where the index of refraction is considered to vary only in the vertical direction.

R. E. Langer of the University of Wisconsin discussed the application of the generalized WKB method to tropospheric propagation. The connection formulae were used to relate the solutions for trapped, leaky, and transitional modes, which occur when there is an inversion of the refractive index.

H. G. Booker discussed the theory of scattering of radio waves in the troposphere and ionosphere. A theory was developed for scattering from the E region based on a model of the fine structure of the ionosphere. Phenomena due to turbulence and local inhomogeneities were analyzed and shown to provide a good explanation of sporadic E observations. J. W. Cox suggested the possibility of combining this viewpoint and the thin layer hypothesis into a unified theory.

Two papers by O. E. H. Rydbeck and J. W. Cox presented theories of mode coupling in the ionosphere which would explain the appearance of the observed third trace (z-mode). Mr. Cox developed a theory along the lines of some recent work of T. L. Eckersley in which the existence of the third trace is explained by the coupling of the ordinary and extraordinary rays near the turning point of the former. This effect would be particularly significant in northern latitudes. Professor Rydbeck calculated the intensities for the z-trace and pointed out that to account for the observations it was necessary to consider the collisional frequencies and that the z-trace will occur whenever the collisional frequency is in the neighborhood of certain critical values.

Professor Rydbeck brought with him two films which were presented Tuesday evening showing the development of an ionosphere observatory in the far north of Sweden and recordings of ionospheric activity in the auroral regions. A running commentary by Dr. Rydbeck and the discussion by the audience contributed to making this rather unexpected event both instructive and entertaining.

GUIDED WAVES

R. B. Adler of Massachusetts Institute of Technology discussed waves on inhomogeneous cylindrical structures. An analysis was given of some of the basic properties of exponential modes on passive structures in which the material constants of the medium vary over a cross section. Each mode is usually a TE–TM mixture. It is found that not all the conventional orthogonality conditions hold. Some characteristic features are that propagation constants for modes on a nondissipative structure cannot be complex and that if the system has no opaque confining boundary, the modes do not possess a true cutoff.

MATHEMATICAL PROBLEMS

Manuel Cerrillo, also of MIT, presented several general methods for evaluating frequently occurring integral expressions, associated with wave motion in dispersive media and the formation of transients.

H. Poritsky of General Electric Company discussed the integral expressions involved in the expansion of Weyl's Integral for harmonic spherical waves to spherical waves of arbitrary time variation.

Arrangements are presently being made for publication of the papers which were presented at the symposium. A bound volume entitled *Proceedings of the Symposium on Electromagnetic Waves* will be put out by Interscience publishers and will appear in the spring of next year.

L. Kraus, J. Lurye, J. Shmoys

MEETINGS TO BE HELD

SYMPOSIUM AT OAK RIDGE

The second annual Oak Ridge Summer Symposium, devoted this year to quantum and inorganic chemistry, will be held at Oak Ridge from August 21 to August 31 under the joint sponsorship of the Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies. Last year's symposium was in modern physics. Included among those presenting papers will be Peter Debye of Cornell University, Henry Eyring of the University of Utah, H. S. Harned of Yale, Linus C. Pauling of the California Institute of Technology, and George Scatchard of the Massachusetts Institute of Technology. Additional information on the symposium may be obtained from the University Relations Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tennessee.

RADIOISOTOPE INSTRUMENTATION

A two-week course in instrumentation for radioisotope work will be given by the special training division of the Oak Ridge Institute of Nuclear Studies from September 5 to 15. The course will be open to physicists, electrical engineers, and others specializing in instrumentation; a knowledge of nuclear radiation properties and experience in electronic instrument design will be a requirement. The number of participants will be limited to 40. A registration fee of $25, payable on arrival at Oak Ridge, is charged for the course. Participants will be expected to pay their own living and traveling expenses. Further information may be obtained by writing to the Institute, P. O. Box 117, Oak Ridge, Tennessee.